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CONVERTER

FIELD OF THE INVENTION

The present invention relates to a converter.

BACKGROUND INFORMATION

In the case of converters, is ~~known~~ **conventional** that the actual value I_actual of the motor current can be measured, the current-sensing ~~means~~ **device** being situated in the converter. The signals provided by the current-sensing ~~means~~ **device** of the control electronics are initially supplied to a filter 1, e.g.**,** a PT1 filter, as shown in Figure 1. Therefore, microcontroller 2 is provided with filtered measuring signals, and interference signals become suppressible. The PT1 filter ~~advantageously takes~~ **may take** the form of a low-pass filter having a time constant of, e.g.**,** 20 μs.

In the case of these converters, it ~~is disadvantageous~~ **may be** that when long cables are used between the converter and the powered electric motor, **and** the capacitance of the cable produces recharging-current peaks that are too high. This is because the converters are operated in a pulse-width-modulated manner, and a change in voltage at the output of the converter produces large, short-term, charging-current peaks of this cable capacitance.

SUMMARY

~~Therefore, the object~~ **Example embodiments** of the present invention ~~is to~~ **may** improve the current sensing in converters.

~~The object of the present invention is achieved by the converter having the features indicated in Claim 1.~~

~~In the case~~ **Features** of the converter, ~~the essential features of the present invention are~~ **include** that it at least includes ~~means~~ **device(s)** for measuring the currents supplied to the electric motor that is powered by the converter, the ~~means~~ **device(s)** for current sensing being ~~situated~~ **arranged** inside the converter, and the signals of the ~~means~~ **device(s)** being fed to a nonlinear filter, whose output signals are fed to an additional filter that is connected to an analog-to-digital converter.

~~In this context, it is advantageous~~ **It may be provided** that a high control performance and control quality are attainable in converters, which are connected, in each instance, to the powered electric motor via long cable, for the recharging-current peaks produced due to the high cable capacitance may be effectively filtered away, ~~in particular~~ **e.g.,** at least one order of magnitude more than in the case of a mere PT1 filter. In this context, it ~~is important~~ **may be provided** that not only the peak value of the filtered signal is less, but that above all, the voltage-time area may be provided to be much less than in the case of a PT1 filter or other linear filters as well.

The nonlinear filter is ~~always designed in~~ **arranged** such ~~a manner,~~ that the changes in the value of the current, which are motor-dependent, i.e.**,** determined by the ~~design~~ **arrangement** of the electric motor, are transmitted ~~essentially~~ **substantially** undisturbed. In contrast to this, recharging-current peaks of shorter duration than the characteristic time of the nonlinear filter are suppressed in the measuring signal. However, changes in current that are caused, for example, by mechanical load changes of the rotor of the electric motor are transmitted ~~essentially~~ **substantially** unchanged.

~~In one advantageous refinement, the~~ **The** analog-to-digital converter ~~is~~ **may be** integrated in a microcontroller or microprocessor. In this context, it ~~is advantageous~~ **may be provided** that as few inexpensive components as possible are usable.

~~In one advantageous refinement, the~~ **The** nonlinear filter ~~is~~ **may be** a run-up transmitter. In this context, it ~~is advantageous~~ **may be provided** that a component is producible, which is ~~especially~~ **particularly** simple to construct.

~~In one advantageous refinement, the~~ **The** run-up transmitter ~~includes~~ **may include** a comparator and an integrator. This ~~offers the advantage~~ **may provide** that standard components may be utilized.

~~In one advantageous refinement, the~~ **The** additional filter ~~is~~ **may be** a PT1 filter. This ~~offers the advantage~~ **may provide** that the circuitry of the related art only requires a few simple modifications.

~~In one advantageous refinement, the~~ **The** value corresponding to the rated current of the converter ~~is~~ **may be** attainable for the run-up transmitter in a time between**, e.g.,** 5 and 10 μs. This ~~provides the advantage~~ **may provide** that the filtering is highly effective and the voltage-time area is much less than in the case of using a PT1 filter having a corresponding time constant.

~~In one advantageous refinement, the~~ **The** PT1 filter ~~has~~ **may have** a time constant having a value between**, e.g.,** 15 and 25 μs, ~~in particular~~ **e.g.**, approximately 20 μs. This ~~provides the advantage~~ **may provide** that **conventional** components ~~of the related art~~ are usable.

~~Further advantages are yielded from the dependent claims.~~

~~List of reference numerals~~

LIST OF REFERENCE CHARACTERS

1 filter

2 microcontroller

3 run-up transmitter

31 comparator

32 integrator having a level converter

41 operational amplifier

42 operational amplifier

R1 resistor

R2 resistor

C1 capacitor

C2 capacitor

~~The~~ **Example embodiments of the** present invention ~~will now be~~ **are** explained in **more** detail **below** with reference to ~~figures:~~ **the appended Figures.**

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a conventional filter.

Figure 2 illustrates an example embodiment of the present invention.

Figure 3 illustrates an example embodiment of the present invention.

Figure 4 is a circuit layout diagram.

Figure 5 illustrates a pulse.

Figure 6 illustrates a response of a conventional PT1 filter.

Figure 7 illustrates a response of a run-up transmitter.

Figure 8 illustrates a response of a filter connected to a run-up transmitter.

BRIEF DESCRIPTION OF THE DRAWINGS

~~A principal feature~~ **Certain features of example embodiments** of the present invention ~~is sketched~~ **are illustrated** in Figure 2. A run-up transmitter 3 is connected in outgoing circuit to the current-sensing ~~means~~ **device**. The output signal of the run-up transmitter is subjected to the usual filtering, i.e.**,** fed to low-pass filter 1, and the signals filtered in this manner are then fed to the microcontroller.

In ~~the~~ **an** ideal case, the run-up transmitter has the characteristic that its output signal increases at a fixed

rate of change, as long as the output voltage is less than the input voltage. In ~~the same way~~ **a similar manner**, its output signal decreases at a fixed rate of change, as long as the output voltage is greater than the input voltage. Therefore, when the input signal changes more slowly than what corresponds to these two rates of change, then the output signal is equal to the input signal. Deviations from this ideal behavior **may** occur in practice.

A basic ~~design~~ **arrangement** of the run-up transmitter is ~~shown~~ **illustrated** in Figure 3. In this context, the output of a comparator 31 is fed to an integrator 32, and the output signal of integrator 32 is used by comparator 31. Therefore, as long as there is a difference between the input and output variables of the run-up transmitter ~~according to~~ **illustrated** Figure 3, the output of comparator 31 will have a positive or negative value as a function of the algebraic sign of the difference. The output signal of integrator 32 increases linearly with time or decreases linearly with time. All in all, a short-term, rectangular input variable is converted into a small triangular pulse. The slope of the triangular waveform is a function of the time constant of the integrator. In **example embodiments of** the present invention, this is selected to be greater than the typical duration of the recharging-current peak for the charging of the cable capacitances.

The maximum slope of the output signal of the run-up transmitter is selected so that its magnitude is ~~always~~ greater than the maximum slopes of the motor-current characteristic. These slopes of the motor-current characteristic are ~~essentially~~ **substantially** determined by the inductance of the electric motor and the applied voltage and the induced voltage in the motor. Therefore, the motor currents are not low-pass filtered, but the current

characteristic to be measured is passed through the subsequent circuit elements ~~essentially~~ **substantially** unchanged. However, the recharging-current peaks are sharply reduced, because they have a considerably greater slope than the mentioned, maximum voltage of the output signal of the run-up transmitter.

~~A concrete~~ **An** example of a circuit layout is ~~shown~~ **illustrated** in Figure 4. However, other circuit layouts may also be ~~advantageously~~ used ~~for implementing the present invention~~. In Figure 4, the comparator is implemented with the aid of operational amplifier 41, as well as the surrounding circuit elements. Its output signals are fed to integrator 42, R4, R5, R6, R7, and C1 with level conversion, this integrator having a time constant between**, e.g.,** 2 and 10 μs, and operational amplifier 42 being provided to be used for level conversion. The output signal is fed back to the input of the comparator via resistor R8. Capacitor C2 is used to prevent the set-up from oscillating. Further components are also provided and dimensioned for preventing oscillation, such as C3. The comparator is implemented as an amplifier having a high gain, which is determined by R1, R9, R2, and R8.

~~Shown~~ **Illustrated** in Figure 5 is an example of a pulse, which ~~symbolically sketches~~ **schematically illustrates** the time characteristic of a recharging-current peak normalized to 1, the recharging-current peak having a pulse width of somewhat greater than 1 μs. In the case of shielded cables several meters long, for example 20 m, ~~real~~ recharging-current peaks **may** exhibit peak values of several ampere, for example 10 ampere and greater. The real time characteristics are not rectangular pulses as ~~shown~~ **illustrated** in Figure 5, but have a sharply damped oscillatory characteristic, which is also determined by the inductance of the cable and by other variables. However, the symbolic shape of the recharging-

current peak is used for more effectively understanding **example embodiments of** the present invention and the behavior of the run-up transmitter in comparison with ~~the related art~~ **conventional arrangements**. The voltage-time area of the represented, symbolic recharging-current peak is comparable to ~~real~~ recharging-current peaks.

Figure 6 ~~shows~~ **illustrates** the ~~measured~~ response of a conventional PT1 filter having a time constant of 20 µs, to the recharging-current peak ~~of~~ **illustrated in** Figure 5. This corresponds to ~~the related art~~ **conventional arrangements**. The filtered value reaches a magnitude of 0.08, i.e.**,** 8% of the ~~real~~ recharging-current peak. The discharging time of the PT1 filter is very long. The voltage-time area is very large as well.

Figure 7 ~~shows~~ **illustrates** the ~~measured~~ response of the run-up transmitter to the recharging-current peak ~~of~~ **illustrated in** Figure 5. The peak value reaches a magnitude of 0.05, i.e.**,** only 5% of the ~~real~~ recharging-current peak. The discharging time of the run-up transmitter is very short and is approximately**, e.g.,** 2 µs. The voltage-time area is very small as well. Deviations from ~~the~~ **an** ideal triangular shape of the response result from the fact that the comparator does not have an infinitely high amplification, but only a finite amplification for suppressing oscillatory behavior.

Operational amplifier 41 ~~is advantageously~~ **may be** selected to from saturation into the active control range within less than**, e.g.,** 200 ns.

Figure 8 ~~shows~~ **illustrates** the ~~measured~~ response, when conventional filter 1 is connected in outgoing circuit to run-up transmitter 3. It is ~~clearly evident~~ **illustrated** that the

recharging-current peak has only a very small effect on the output signal fed to microcontroller 2.

Therefore, **example embodiments of** the present invention ~~provides~~ **may provide** a nonlinear filter, which ~~suppresses~~ **may suppress** recharging-current peaks in a highly effective manner and, consequently, also **may allow** ~~allows~~ a very high control quality in the case of converters having long cables leading to the powered motor.

~~Abstract~~

ABSTRACT

A converter~~, comprising~~ **includes** at least ~~means~~ **device(s)** for sensing the currents fed to the electric motor powered by the converter, the ~~means~~ **device(s)** for current detection being ~~situated~~ **arranged** inside the converter, and the signals of the ~~means~~ **device(s)** being fed to a nonlinear filter, whose output signals are fed to an additional filter that is connected to an analog-to-digital converter.